NASA Contractor Report 2856

Equation Modifying Program, L219 (EQMOD)

Volume II: Supplemental System Design and Maintenance Document

M. Y. Hirayama, R. E. Clemmons,
and R. D. Miller

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Scientific and Technical
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1.0 SUMMARY

Program L219 (EQMOD) is structured as eight overlays, one main, four primary, and three secondary overlays. Input into the program is made via cards and magnetic files (tapes or disks). Output from the program consists of printed results and magnetic files containing modified copies of the input matrices.

Although L219 (EQMOD) serves as a module of the DYLOFLEX system, it can be operated as a standalone program. Subroutines used by L219 include routines embedded in the program code and routines obtained from the standard FORTRAN, DYLOFLEX, and FLEXSTAB libraries.

2.0 INTRODUCTION

Program L219 (EQMOD) can be used as either a standalone program or as a module of a program system called DYLOFLEX (see fig. 1) which was developed for NASA under contract NAS1-13918 (ref. 1). Because of the DYLOFLEX contract requirements developed in reference 2, a program was needed to modify the equations of motion matrices generated by L217 (EOM) of reference 3 and the load equation matrices generated by L218 (LOADS) described in reference 4. The matrices are modified to include:

- Scalar multipliers
- Replace or increment individual matrix elements
- Add sensor equations to the equations of motion
- Add the definition of the active control system to the equations of motion
- Replace the rigid body stability derivatives in the equations of motion with those calculated by FLEXSTAB (ref. 5) or other external means
- Transform the equations of motion and load equations from the inertia axis system to the body axis system
- Prepare the matrix coefficients in a form usable by the Linear System Analysis program QR (ref. 6). including:
    - Equations of motion with and without Wagner lift growth functions
    - Equations of motion and load equations combined for a time history solution

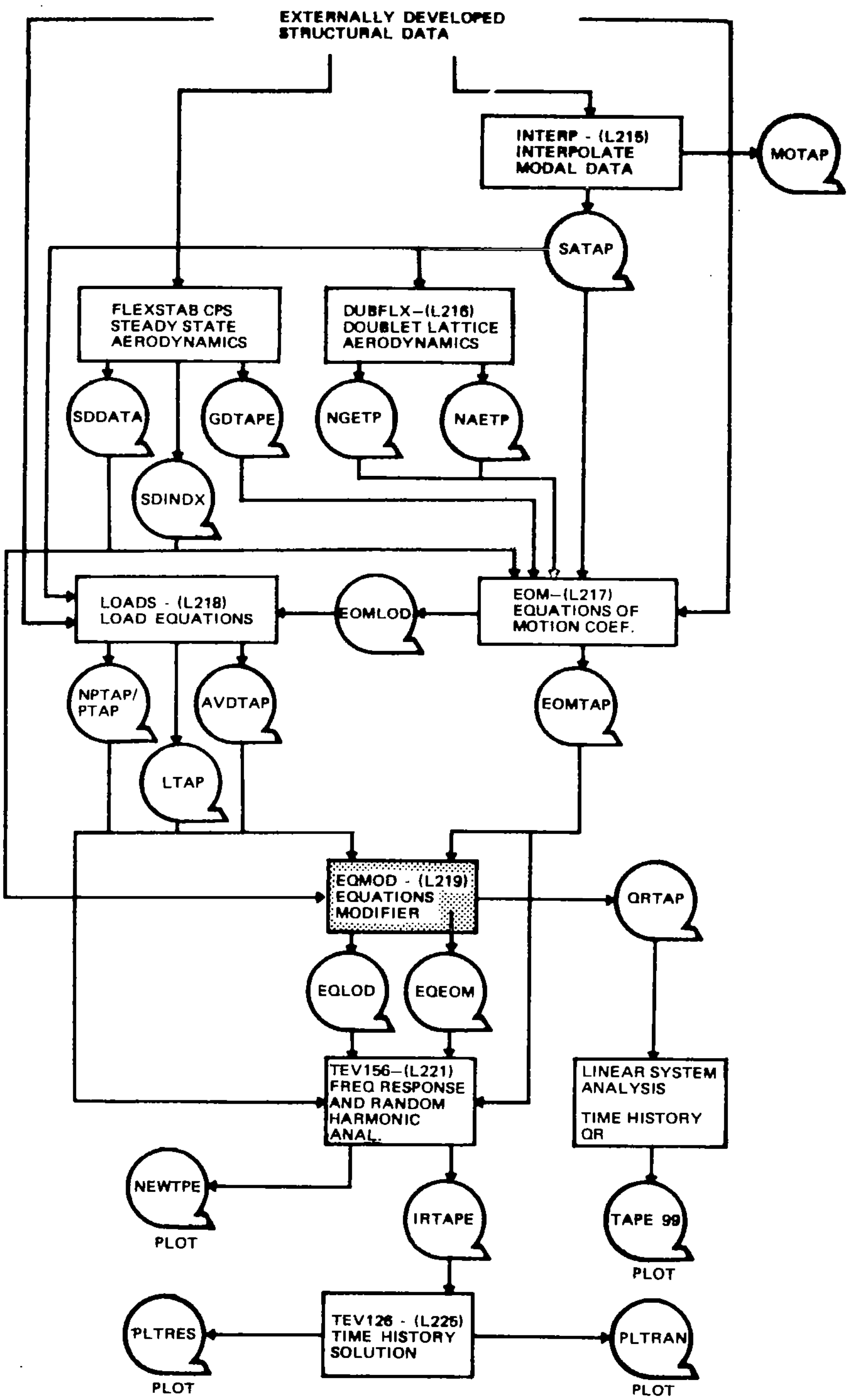

Figure 1.— DYLOFLEX Flow Chart

The objective of this volume is to aid those persons who will maintain and/or modify the program in the future. To meet this objective, the following items are defined in detail:

- Program design and structure
- Overlay purpose and description
- Input, output and internal data base descriptions
- Test cases

The program was designed, coded, and tested according to the DYLOFLEX programming specifications.[1]

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[1]R. E. Clemmons: *Programming Specifications for Modules of the Dynamic Loads Analysis System to Interface with FLEXSTAB*. NASA contract NAS1-13918, BCS-G0701 (internal document), September 1975.

3.0 PROGRAM DESIGN AND STRUCTURE

Program L219 (EQMOD) has been constructed as an overlay system consisting of a main overlay, four primary and three secondary overlays (see fig. 2).

Main overlay (L219,0,0)	L219vc
Primary overlay (L219,1,0)	RDCRDS
Secondary overlay (L219,1,1)	RDEOM
Secondary overlay (L219,1,2)	RDLOD
Secondary overlay (L219,1,3)	RDQR
Primary overlay (L219,2,0)	EOMMOD
Primary overlay (L219,3,0)	LODMOD
Primary overlay (L219,4,0)	QRMOD

The input and output of EQMOD are displayed in figure 3. The file scratch random file SCRAND is used for temporary storage of data by EQMOD. The other files communicate with programs outside of EQMOD.

The main overlay L219vc initializes the program's default values and the scratch random file, determines which primary overlays are to be executed, and aids communication between the overlays through labeled common blocks. The characters v and c in the program name stand for version and correction respectively (see sec. 3.1).

The 1,0 primary overlay RDCRDS reads and edits common input data, writes diagnostics when errors are detected, and determines which secondary overlays are to be executed. In addition, if FLEXSTAB rigid body stability derivatives are requested, RDCRDS will read the stability derivatives from file SDSSTP. The data read from cards and SDSSTP are stored in labeled common blocks and in arrays written onto the scratch random file SCRAND. RDCRDS calls RDEOM, RDLOD, and RDQR overlays to perform portions of its tasks.

The 1,1 secondary overlay RDEOM reads and edits all Equations of Motion (L217) input data, writes error diagnostics when an error occurs, and stores edited data on the scratch random file SCRAND.

The 1,2 secondary overlay RDLOD reads and edits all Load Equations (L218) input data, writes error diagnostics when an error occurs, and stores edited data on the scratch random file SCRAND.

The 1,3 secondary overlay RDQR reads and edits all Linear Systems Analysis QR program input data, writes error diagnostics when an error occurs, and stores edited data on the scratch random file SCRAND.

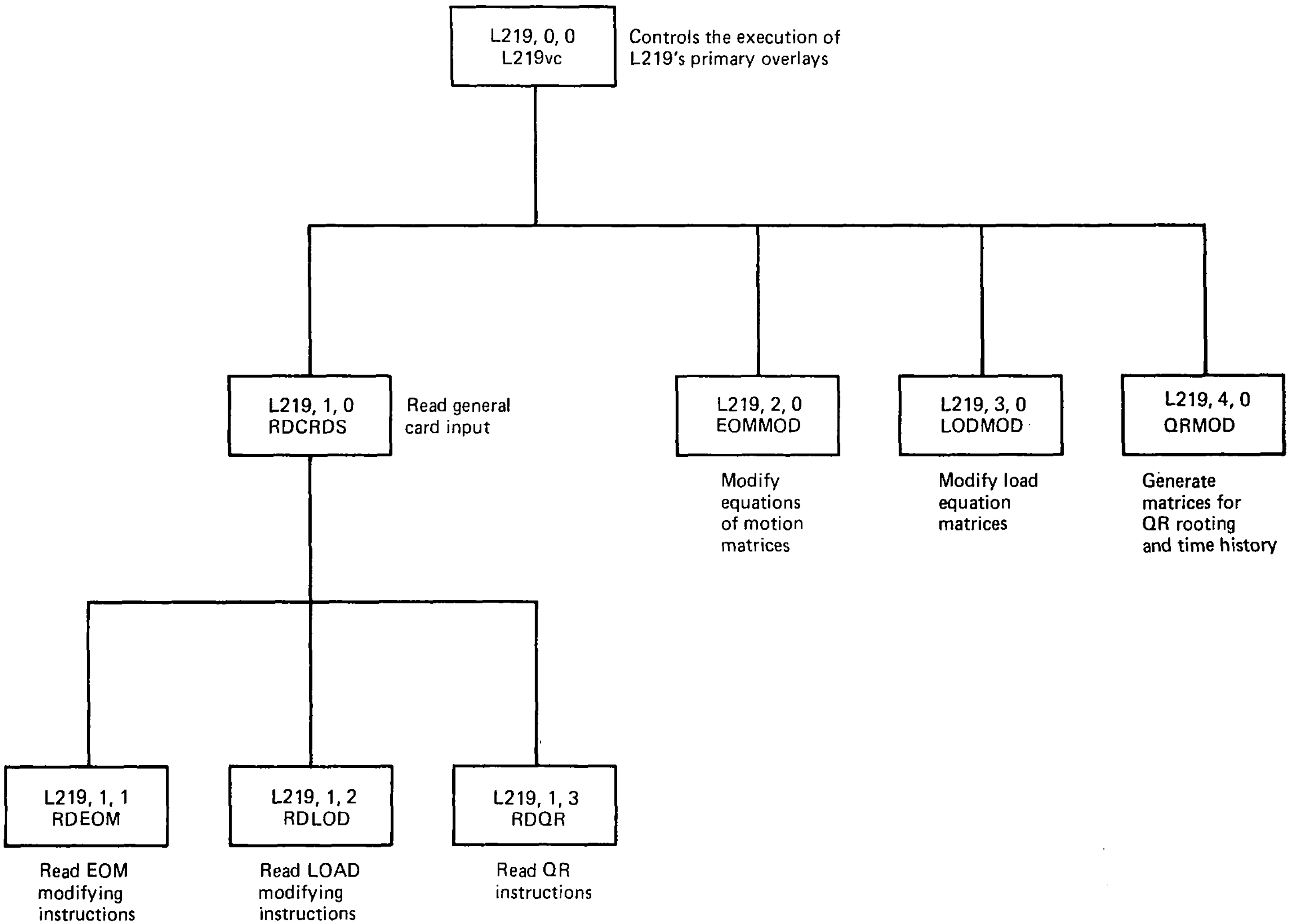
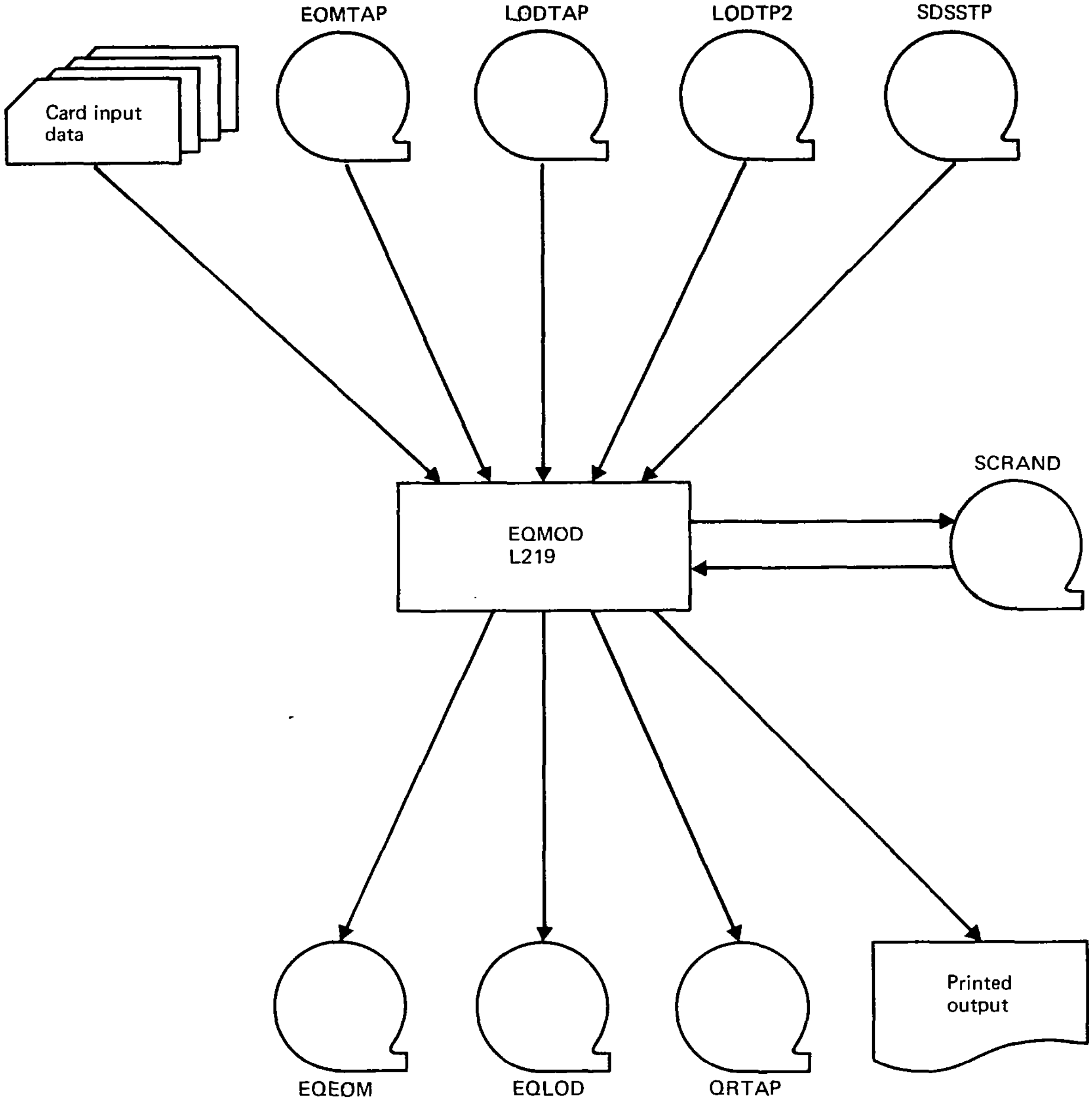


Figure 2.—Overlay Structure of L219 (EQMOD)



The input and output magnetic files have variable user specified names.

Figure 3.—Input/output of L219 (EQMOD)

The 2,0 primary overlay EOMMOD modifies all of the matrix coefficients from the Equations of Motion (L217) program according to the instructions specified on input cards.

The 3,0 primary overlay LODMOD modifies all of the matrix coefficients from the Load Equations (L218) program according to the instructions specified on input cards.

The 4,0 primary overlay, QRMOD generates rooting and time solution matrices for the Linear Systems Analysis, QR, program.

Each overlay is discussed in detail in succeeding sections. Included for each overlay are:

1. The overlay's purpose.
2. The overlay's analytical steps.
3. The input/output devices used.
4. A macro flow chart.
5. Table of subroutines called. (Note: all subroutines have only one entry point.)

3.1 MAIN OVERLAY (L219,0,0)-L219vc

The main overlay of L219 (EQMOD) is L219vc, where v is a letter indicating the program version, and c is an integer number indicating the correction number which applies to the v version.

Purpose of L219vc

L219vc performs certain bookkeeping tasks, directs the execution of the primary overlays, and aids communication between primary overlays via labeled common blocks.

The macro flow chart of this overlay is shown in figure 4. The subroutines called are displayed in table 1.

I/O Devices of L219

L219 reads a data card (card set 1.0) and writes diagnostics on the output file if errors are encountered. All other I/O accomplished by L219 (EQMOD) is done in lower level overlays.

3.2 PRIMARY OVERLAY (L219,1,0)-RDCRDS

Purpose of RDCRDS

The primary overlay RDCRDS is called to read and edit common input data, print a diagnostic when an error is detected, and call secondary overlays to read L217 (EOM), L218 (LOADS), and QR input data.

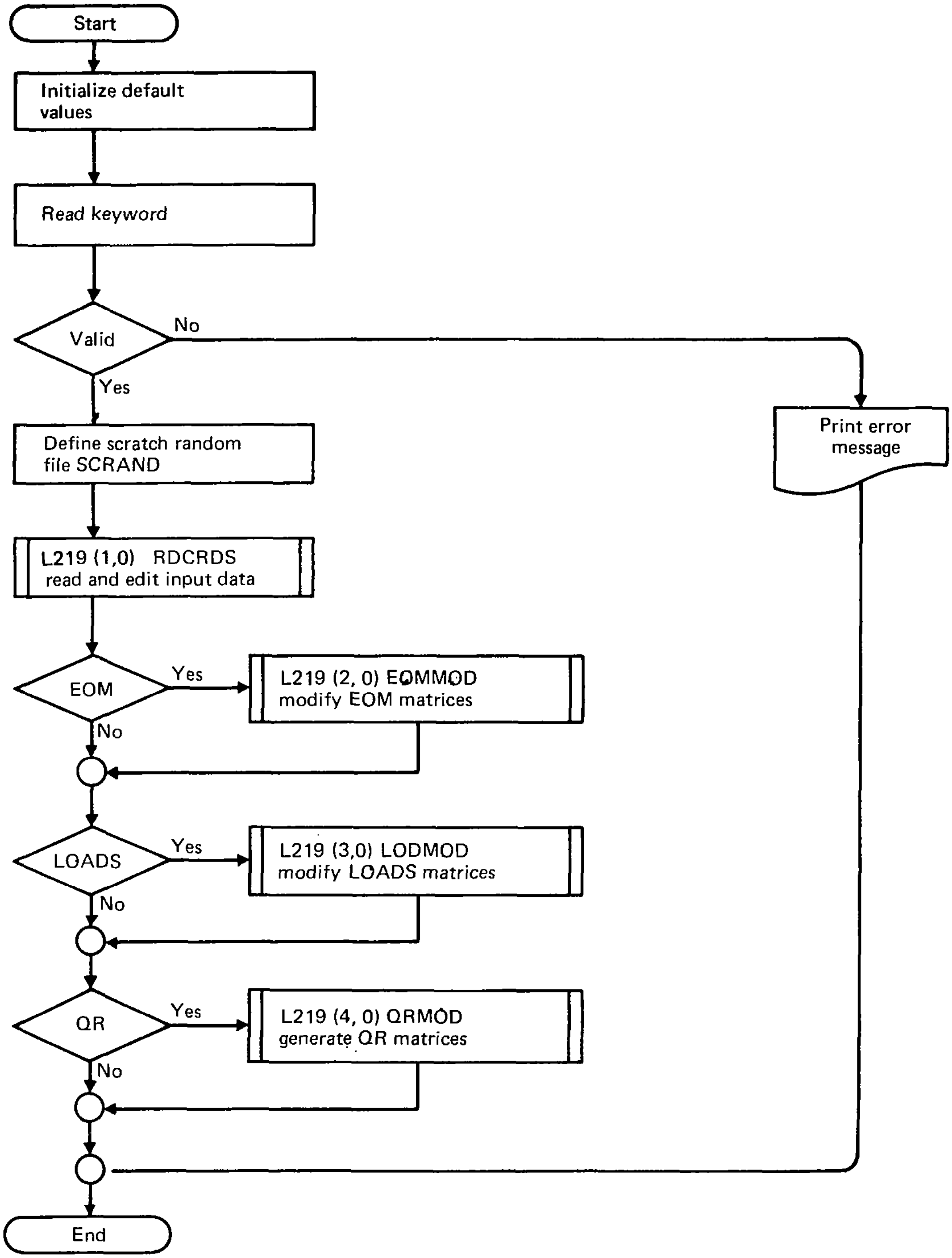


Figure 4.—Macro Flow Chart of Overlay (L219, 0, 0)-L219vc

Table 1.—Routines Called by L219vc

```
OVERLAY (L219,0,0)

PROGRAM L219vc
-------------------------------------------------------------------
                    RDCRDS (Overlay L219,1,0)

                    EOMMOD (Overlay L219,2,0)

                    LODMOD (Overlay L219,3,0)

                    QRMOD (Overlay L219,4,0)

                    CLOSMS *

                    DATE *

                    FETAD +

                    FETDEL +

                    IPQL +

                    KEYWRD    calls EOF *

                    OPENMS *

                    OVERLAY *

                    PRGBEG +

                    PRGEND +

                    RETURNF +
```

+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

Analytical Steps of RDCRDS

RDCRDS reads a card, extracts the keyword code, and performs one of the following tasks before reading another keyword card.

- Store title card
- Define problem size
- Define output tape name and matrix positions
- Define print option data
- Set symmetric/antisymmetric indicator
- Call program RDEOM to read and edit EOM data
- Call program RDLOD to read and edit LOADS data
- Call program RDQR to read and edit QR data
- Print error diagnostics when errors are detected

The macro flow chart of this overlay is shown in Figure 5. The subroutines called are displayed in table 2.

I/O Devices of RDCRDS

RDCRDS reads card sets 1.0 through 19.0 and echo prints the input data and diagnostics for all errors detected.

3.2.1 SECONDARY OVERLAY (L219,1,1)-RDEOM

Purpose of RDEOM

The secondary overlay RDEOM is called to read and edit all Equations of Motion L217 (EOM) input data, write error diagnostics when an error is detected, and store edited data on scratch random file SCRAND for the EOM equation matrix modifier program.

Analytical Steps of RDEOM

RDEOM has the following three steps:

1. Decode $EOM card for input tape name, matrix file position, and null matrix indicators.

2. Read a card, find keyword code, and perform one of the following tasks:

    - Call RDDERS or RDDERA to read, edit, and calculate derivatives for symmetric or antisymmetric analysis, respectively
    - Call RDSEN to read and edit all sensor data.
    - Call RDSAS to read and edit all active control system definition data
    - Call RDSCAL to read and edit all matrix scalar data

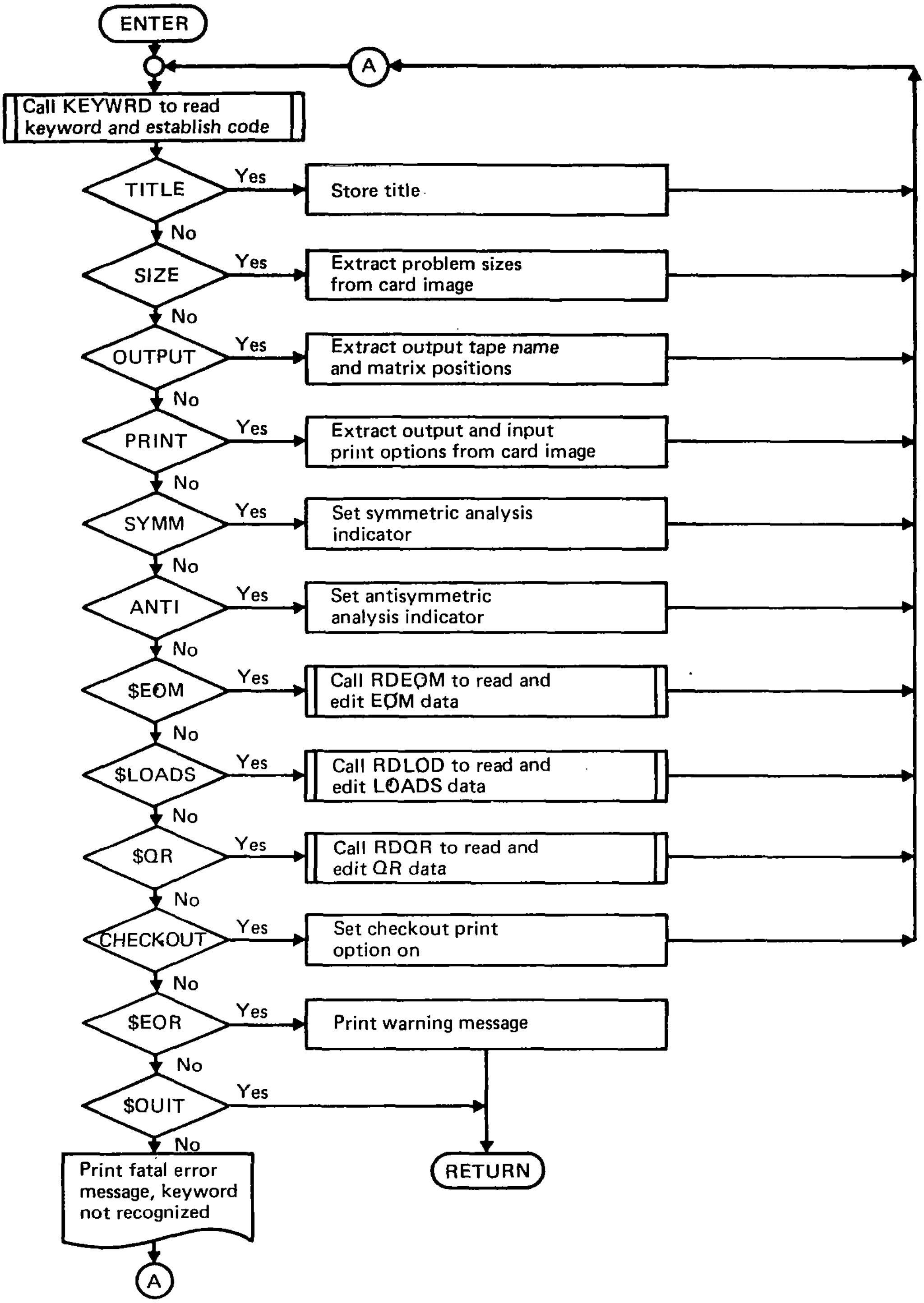


Figure 5.—Macro Flow Chart of Overlay (L219, 1, 0)—RDCRDS

Table 2.—Routines Called by RDCRDS

```
OVERLAY (L219,1,0)

PROGRAM RDCRDS

----------------------------------------------------------------------

                    RDEOM (Overlay L219,1,1)

                    RDLOD (Overlay L219,1,2)

                    RDQR (Overlay L219,1,3)

                    KEYWRD

                    NAMFIL +

                    OVERLAY *
```

\+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

- Call RDINRE to read and edit all matrix element replacement and increment data
- Read and edit body axis symmetric or anti-symmetric data

3. Print diagnostic messages for all errors detected. The macro flow chart for RDEOM is in figure 6. The subroutines called are displayed in table 3.

I/O Devices of RDEOM

RDEOM reads card sets 7.0 through 13.0. It prints the calculated values with descriptive captions.

RDEOM reads the header matrix from the file EOMTAP if the file was generated by the DYLOFLEX program L217 (EOM) (ref. 4).

RDEOM writes on the scratch random file SCRAND all the edited EOM input data, the edited derivatives, and the active control system definition data.

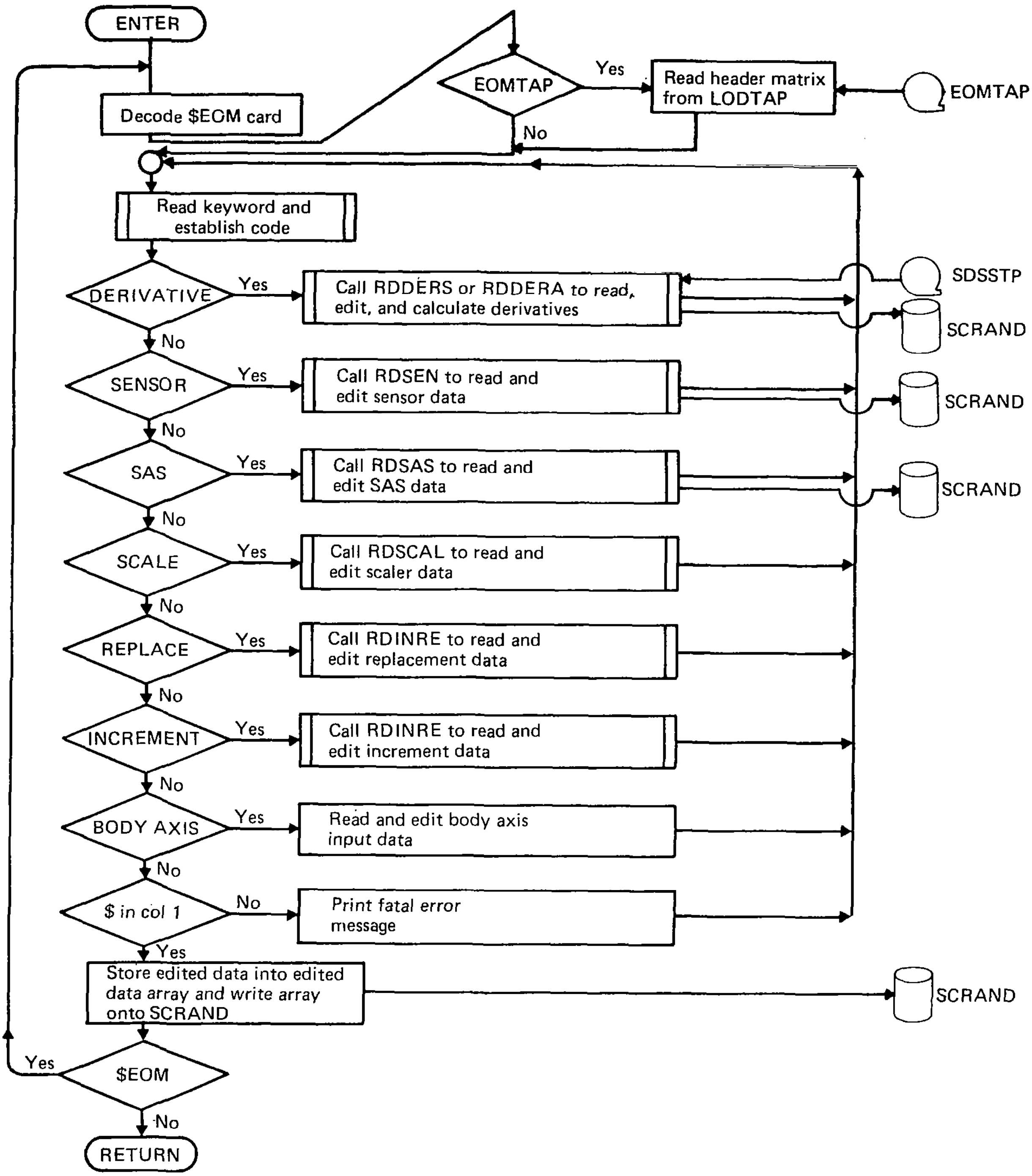


Figure 6.—Macro Flow Chart of Overlay (L219, 1, 1)—RDEOM

Table 3.—Routines Called by RDEOM

```
OVERLAY (L219,1,1)

PROGRAM RDEOM

-----------------------------------------------------------------

RDEOM     calls     FETAD +
                    FETDEL +
                    KEYWRD
                    NAMFIL +
                    RDDERA    calls    CLRTAB $
                                       DMPTAB $
                                       FETAD +
                                       FETCHM +
                                       FETDEL +
                                       INPTAB $
                                       PRNTM
                                       WRITMS *

                    RDDERS    calls    CLRTAB $
                                       DMPTAB $
                                       FETAD +
                                       FETCHM +
                                       FETDEL +
                                       INPTAB $
                                       PRNTM
                                       WRITMS *
```

Table 3.—(Concluded)

RDINRE	calls	IRQL +
		KEYWRD
RDSAS	calls	KEYWRD
		WRITMS *
RDSCAL	calls	KEYWRD
RDSEN	calls	KEYWRD
		NAMFIL +
		WRITMS *
READTP +		
WRITMS *		

$ indicates a FLEXSTAB library routine

+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

3.2.2 SECONDARY OVERLAY (L219,1,2)-RDLOD

Purpose of RDLOD

The secondary overlay RDLOD is called to read and edit all Load Equations L218 (LOADS) input data, write an error diagnostic when an error is detected, and store edited data on scratch random file SCRAND for the LOADS equation matrix modifier program.

Analytical Steps of RDLOD

RDLOD has the following four steps:

1. Check if maximum number of LOADS sets processed

2. Decode $LOADS card for input tape name, matrix file position, number of output loads, and null matrix indicators

3. Read a card, find keyword code, and perform one of the following tasks:

    - Call RDSCAL to read and edit all matrix scalar data
    - Call RDINRE to read and edit all matrix element replacement and increment data

4. Print error diagnostic when an error is detected

Figure 7 is a macro flow chart of RDLOD. Table 4 displays the routines called by RDLOD.

I/O Devices of RDLOD

RDLOD reads card sets 15.0 through 17.0.

If the loads input magnetic file, LODTAP was generated by the DYLOFLEX program L218 (LOADS) (ref. 4), the header array is read by RDLOD to determine which load matrices are available and their size.

The input data and diagnostics are printed with descriptive labels. The edited loads input data is saved on the scratch random file SCRAND.

3.2.3 SECONDARY OVERLAY (L219,1,3)-RDQR

Purpose of RDQR

The secondary overlay RDQR is called to read and edit all Linear Systems Analysis (QR) input data, write error diagnostics when an error is detected, and store edited data on the scratch random file SCRAND for the QR matrix generation overlay, QRMOD.

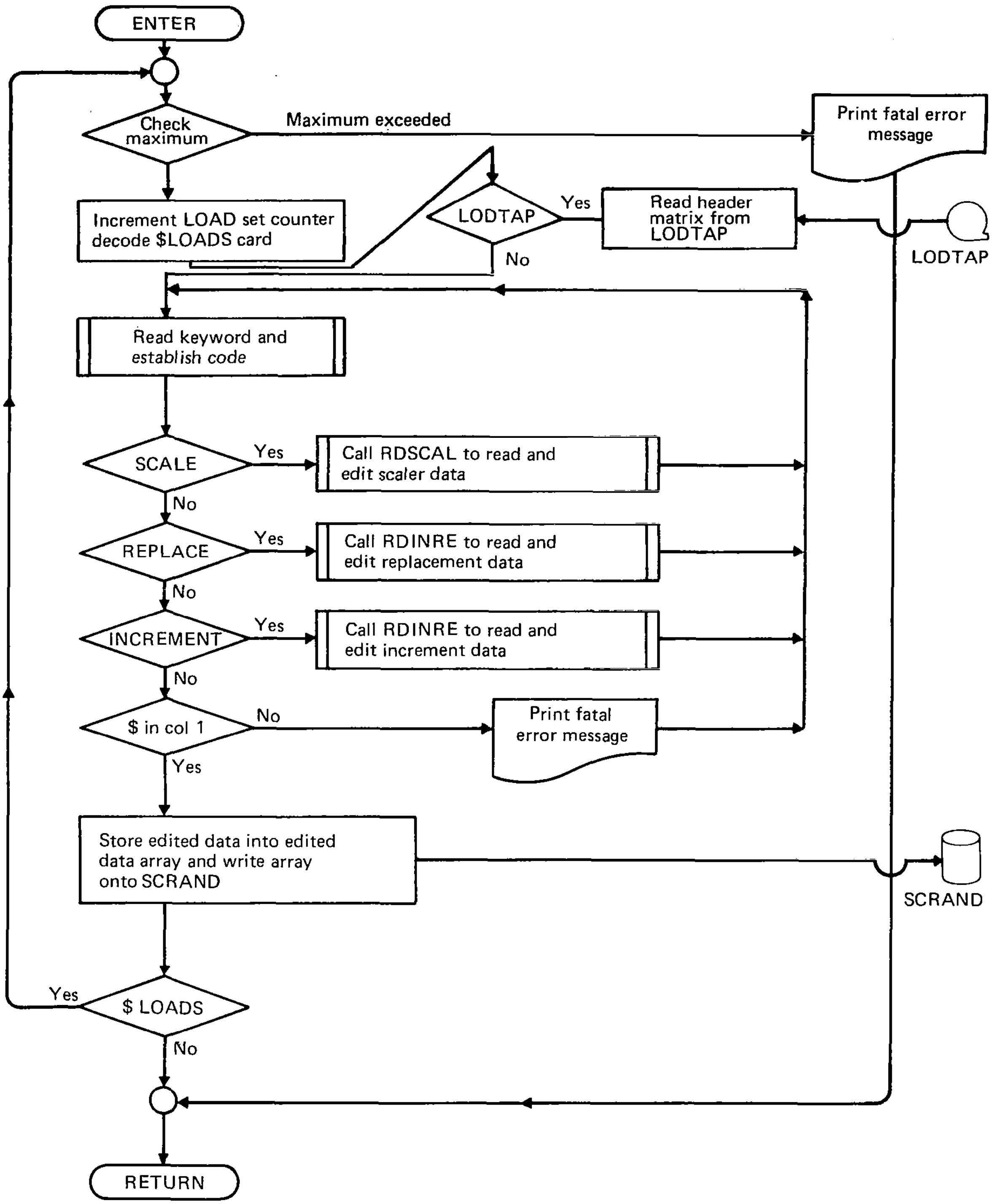


Figure 7.—Macro Flow Chart of Overlay (L219, 1, 2)—RDLOD

Table 4.—Routines Called by RDLOD

```
OVERLAY (L219,1,2)

PROGRAM RDLOD

----------------------------------------------------------------

RDLOD     calls     FETAD +
                    FETDEL +
                    KEYWRD
                    NAMFIL +
                    RDINRE    calls     IRQL +
                                        KEYWRD
                    RDSCAL    calls     KEYWRD
                    READTP +
                    WRITMS *
```

\+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

Analytical Steps of RDQR

RDQR program has the following four steps:

1. Check if the maximum number of QR sets has been processed

2. Decode $QR card for output tape name and matrix positions

3. Read a card, find keyword code, and perform one of the following tasks:

   - Read the EOM input tape name, matrix position, and null matrix indicators
   - Set Wagner function indicator and read Wagner functions
   - Set rooting function indicator
   - Set time solution indicator
   - Read the LOADS input file name, matrix position, number of loads, and null matrix indicators

4. Print error diagnostics when errors are detected.

Figure 8 is the macro flow chart of RDQR. Table 5 displays the subroutines called by RDQR.

I/O Devices of RDQR

RDQR reads cards 18.2 through 18.6. RDQR prints the card input data and diagnostics for errors detected. The edited QR input data is written onto the scratch random file SCRAND.

3.3 PRIMARY OVERLAY (L219,2,0)-EOMMOD

Purpose of EOMMOD

The primary overlay EOMMOD is called to modify all the matrix equations from the L217 (EOM) program according to the instructions specified on the input cards.

Analytical Steps of EOMMOD

EOMMOD has the following nine steps:

1. Read edited input data from SCRAND

2. Establish pointers for variably dimensioned matrices M_1, M_2, M_3, and the active control system and sensor data

3. Check field length available against that required

4. Establish FET and buffer areas for input EOM file and read the header record if the EOM file was generated in the DYLOFLEX system.

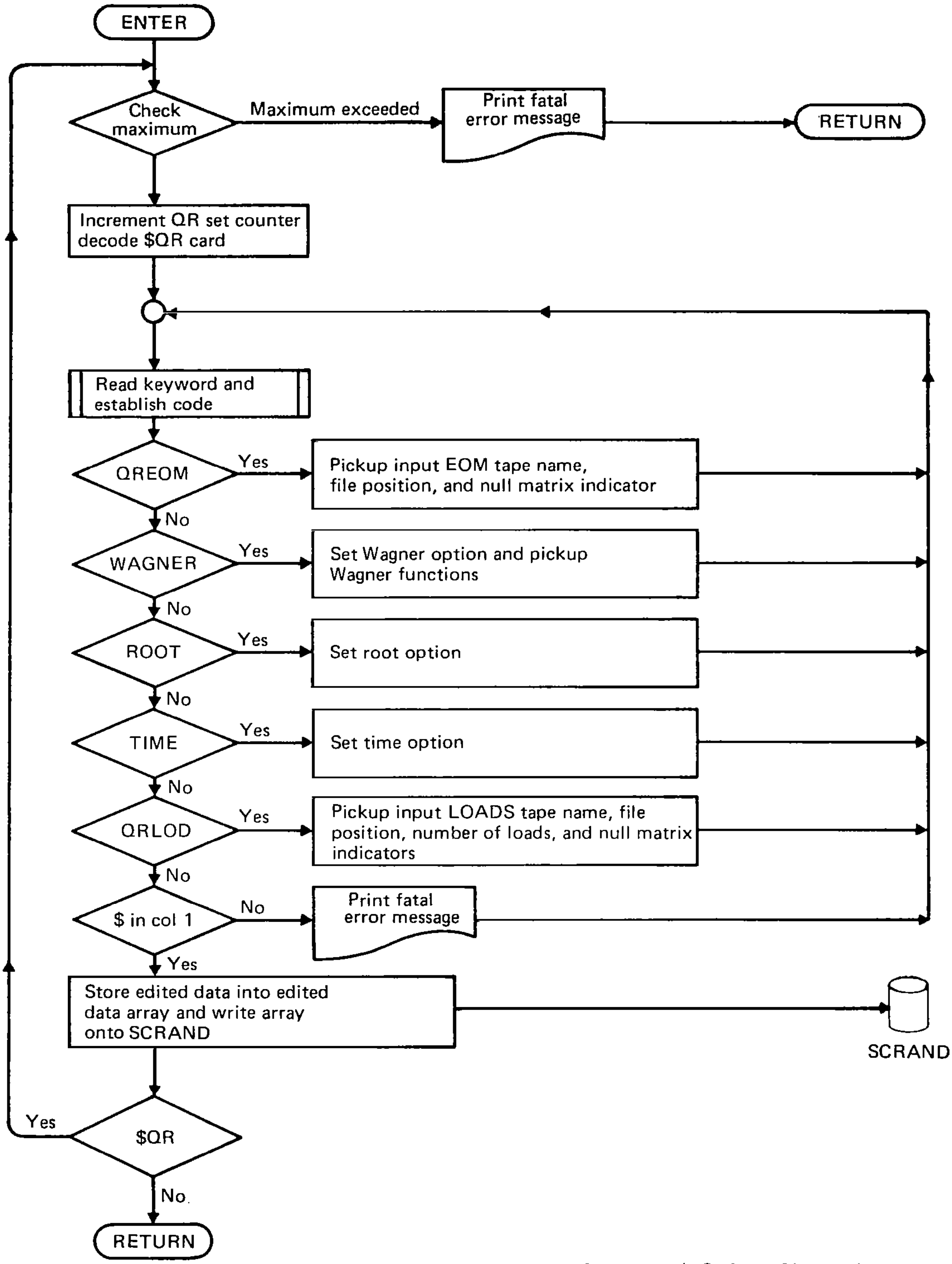


Figure 8.—Macro Flow Chart of Overlay (L219, 1, 3)—RDQR

Table 5.—Routines Called by RDQR

```
OVERLAY (L219,1,3)

PROGRAM RDQR
--------------------------------------------------------------

    RDQR calls          KEYWRD

                        NAMFIL +

                        WRITMS *
```

\+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

5. Call subroutine M123 to read, modify, and write the M_1, M_2, and M_3 matrices with scalar, replacement, increment, sensor, active control system definition, and body axis data

6. Establish pointers for variably dimensioned matrices M_4, M_5, and f_ℓ and C_3 or $\tilde{\phi}$.

7. Check field length available against that required

8. Call subroutine M45CP to read, modify, and write all the M_4, M_5, f_ℓ , C_3, and $\tilde{\phi}$ matrices with derivative, scalar, replacement, increment, and body axis data

9. Print error diagnostics when errors are detected

Figure 9 is a macro flow chart of EOMMOD. Table 6 displays the subroutines called by EOMMOD.

I/O Devices of EOMMOD

EOMMOD reads data from the following files:

EOMTAP	Header array plus the matrices M_1, M_2, M_3, FREQM, M_4, M_5, and C_3 (or f_ℓ and $\tilde{\phi}$)
LODTP2	(Only if sensor equations are being added) the matrices $\overline{M}_1$, $\overline{M}_2$, and $\overline{M}_3$
SCRAND	Edited input EOM data including derivatives, sensor data, and active control system data

EOMMOD writes on two files, the printed output file and EQEOM:

EQEOM	Header array plus the modified matrices M_1, M_2, M_3, FREQM, M_4, M_5, and C_3 (or f_ℓ and $\tilde{\phi}$)
OUTPUT	Modified matrices written on EQEOM are also printed.

3.4 PRIMARY OVERLAY (L219,3,0)–LODMOD

Purpose of LODMOD

The primary overlay LODMOD is called to modify all the matrix equations from the LOADS program according to the instructions specified on the input cards.

Analytical Steps of LODMOD

LODMOD has the following nine steps:

1. Read edited input data from SCRAND

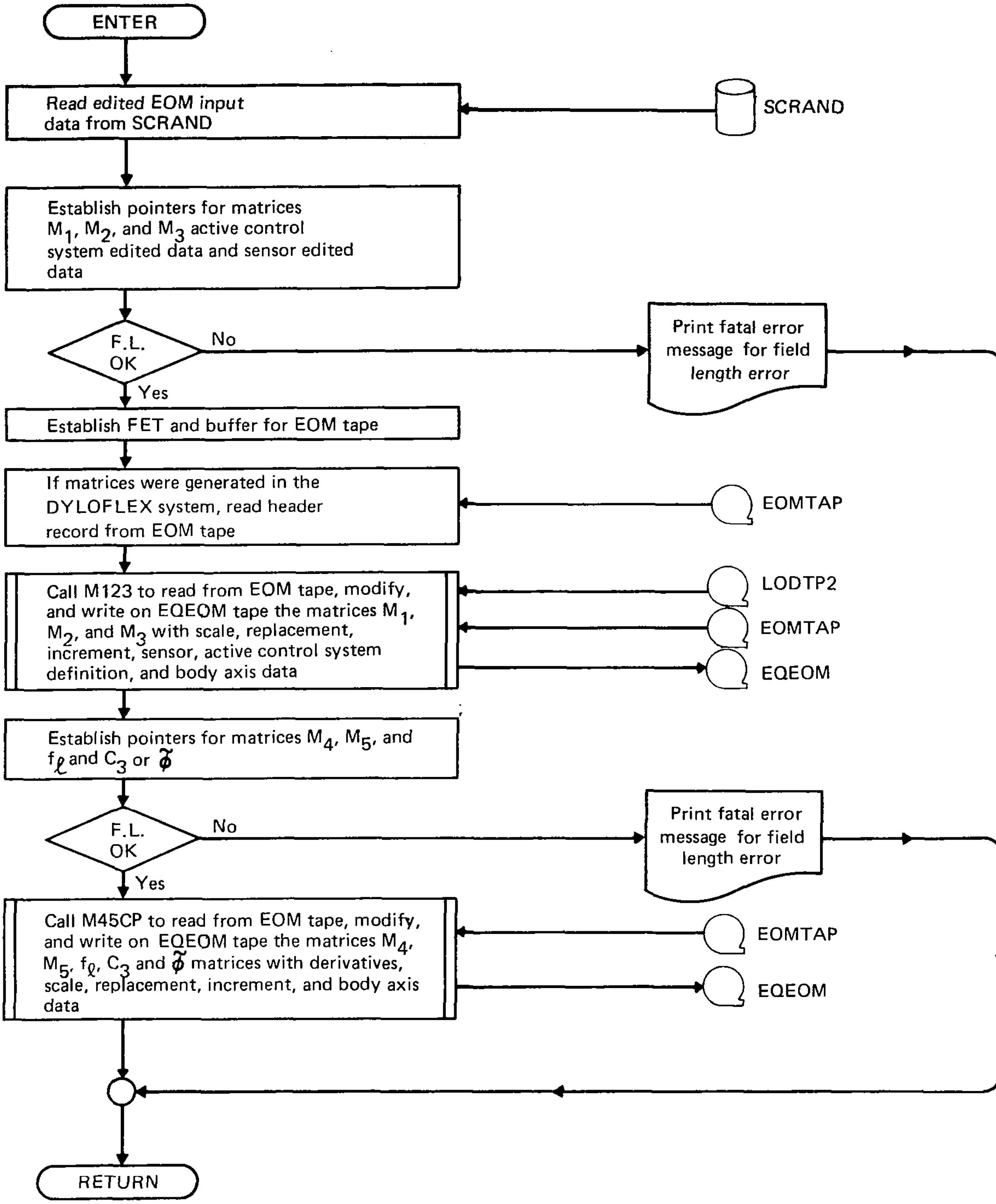


Figure 9.—Macro Flow Chart of Overlay (L219, 2, 0)—EOMMOD

Table 6.—Routines Called by EOMMOD

```
OVERLAY (L219,2,0)

PROGRAM EOMMOD

----------------------------------------------------------------------

EOMMOD   calls   FETAD+
                 FETDEL +
                 M123     calls   ADDSAS
                                  ADDSEN   calls   FETAD +
                                                   FETDEL +
                                                   PRNTM
                                                   READTP +
                                                   SENSOR
                                  BODM12   calls   WRITMS *
                                  INCRM    calls   IRQL +
                                  PRNTM
                                  READMS *
                                  READTP +
                                  REPLM    calls   IRQL +
                                  SCALM
                                  WRTETP +
                                  ZEROM

                 M45CP    calls   ADDDER   calls   ADDDIN
                                  BODM4    calls   READMS *
                                  INCRM    calls   IRQL +
                                  PRNTM
```

Table 6.—(Concluded)

```
                    READMS *
                    READTP +
                    REPLM      calls      IRQL +
                    SCALM
                    WRTETP +
                    ZEROM

          READMS *
          READTP +
          REQFL +
          LOCF *
          MAXO *
```

+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

2. Establish pointers for variably dimensioned matrices $\overline{M}_1$, $\overline{M}_2$, $\overline{M}_3$, and body axis edited data

3. Check field length available

4. Establish FET and buffer areas for the input LOADS file and read the header record if the LOADS file was generated in the DYLOFLEX system

5. Call routine M123B to read, modify, and write the $\overline{M}_1$, $\overline{M}_2$, and $\overline{M}_3$ matrices with scalar, replacement, increment, and body axis data

6. Establish pointers for variably dimensioned matrices $\overline{M}_4$, $\overline{M}_5$, $\overline{C}_3$ and $\overline{\tilde{\phi}}$.

7. Check field length available

8. Call subroutine M45CPB to read, modify, and write all the $\overline{M}_4$, $\overline{M}_5$, $\overline{C}_3$, and $\overline{\tilde{\phi}}$ matrices with scalar, replacement, increment, and body axis data

9. Print error diagnostics when errors are detected

Repeat steps 1 through 8 for each load set.

Figure 10 is the macro flow chart of LODMOD. Table 7 displays the subroutines called by LODMOD.

I/O Devices of LODMOD

LODMOD reads data from the following files:

LODTAP	Header array plus the matrices $\overline{M}_1$, $\overline{M}_2$, $\overline{M}_3$, $\overline{M}_4$, $\overline{M}_5$ and $\overline{C}_3$ or $\overline{\tilde{\phi}}$.
SCRAND	Edited loads input data and body axis data

LODMOD writes on two files:

EQLOD	Modified loads matrices including the header array and $\overline{M}_1$, $\overline{M}_2$, $\overline{M}_3$, $\overline{M}_4$, $\overline{M}_5$ and $\overline{C}_3$ or $\overline{\tilde{\phi}}$
OUTPUT	Matrices written onto EQLOD will be printed if requested

3.5 PRIMARY OVERLAY (L219,4,0)–QRMOD

Purpose of QRMOD

The primary overlay QRMOD is called to generate rooting and time solution matrices (from the EOM and LOADS equation matrices) for the QR program.

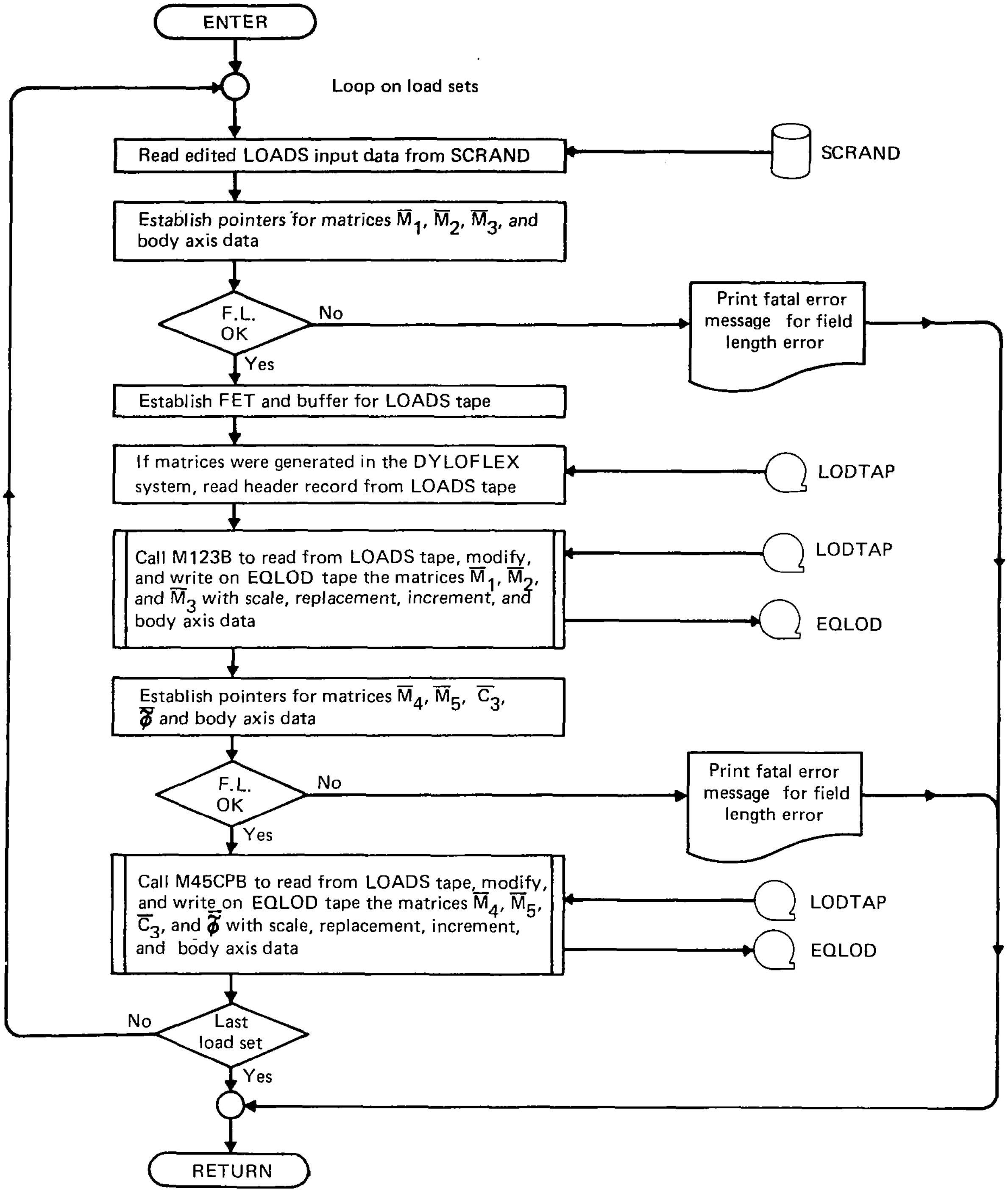


Figure 10.—Macro Flow Chart of Overlay (L219, 3, 0)—LODMOD

Table 7.—Routines Called by LODMOD

```
OVERLAY (L219,3,0)

PROGRAM LODMOD

----------------------------------------------------------------------

LODMOD    calls     FETAD +
                    FETDEL +
                    M123B     calls     BODM12    calls     WRITMS *
                                        INCRM     calls     IRQL +
                                        PRNTM
                                        READTP +
                                        REPLM     calls     IRQL +
                                        SCALM
                                        WRTETP +
                                        ZEROM

                    M45CPB    calls     BODM4     calls     READMS *
                                        INCRM     calls     IRQL +
                                        PRNTM
                                        READTP +
                                        REPLM     calls     IRQL +
                                        SCALM
                                        WRTETP +
                                        ZEROM
```

Table 7.—(Concluded)

READMS *

READTP +

REQFL +

LOCF *

+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

Table 7 (concluded)

Analytical Steps of QRMOD

QRMOD has the following seven steps:

1. Read edited input data from SCRAND
2. Establish FET and buffer area for input EOM file
3. Read EOM equation matrices and write matrices on SCRAND
4. If Wagner option was requested, establish matrix pointers, call routine QRWAGN for QR's rooting matrices with Wagner functions, and then go to step 7.
5. If root option was requested, establish matrix pointers, call routine QRROOT for QR's rooting matrices without Wagner functions, and then go to step 7.
6. If time history option was requested, establish FET and buffer areas for the input LOADS file, read LOADS equation matrices and write matrices on SCRAND, establish matrix pointers, and call QRTIME for QR's time solution matrices
7. Return to calling program.

Repeat steps 1 through 6 for each QR set.

Figure 11 is the macro flow chart of QRMOD. Table 8 displays the subroutines called by QRMOD.

I/O Devices of QRMOD

QRMOD reads from the following files:

EOMTAP or EQEOM	M_1, M_2, M_3, M_4, M_5 and C_3 or $\tilde{\phi}$
LODTAP or EQLOD	$\overline{M}_1$, $\overline{M}_2$, $\overline{M}_3$, $\overline{M}_4$, $\overline{M}_5$ and $\overline{C}_3$ or $\overline{\tilde{\phi}}$
SCRAND	Edited input data for QR

Note: The matrices read from EOMTAP and LODTAP are also temporarily stored on SCRAND.

QRMOD writes on two files:

QRTAP	Matrices which are coefficients of S^4, S^3, S^2, S^1 and S^0
OUTPUT	Matrices written onto QRTAP may be printed by request.

3.6 DATA BASES

The programs data bases include input and output files plus internal scratch (temporary) storage random file and labeled common blocks.

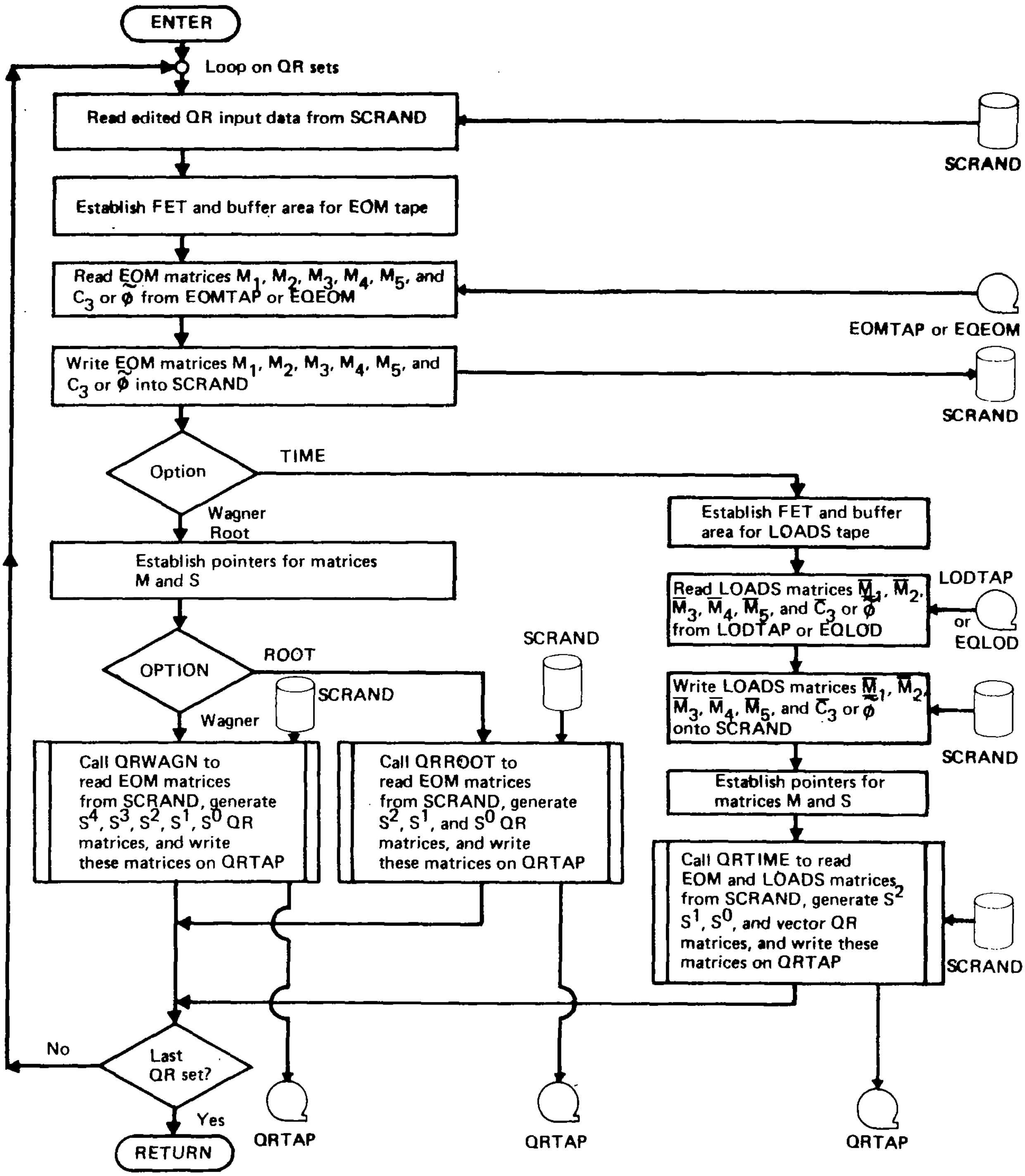


Figure 11. – Macro Flow Chart of Overlay (L219,4,0)–QRMOD

Table 8.—Routines Called by QRMOD

```
OVERLAY (L219,4,0)

PROGRAM QRMOD

-----------------------------------------------------------------------

QRMOD     calls     FETAD +

                    FETDEL +

                    QRROOT     calls     PRNTM

                                         QRMADD

                                         READMS *

                                         WRTETP +

                                         ZEROM


                    QRTIME     calls     PRNTM

                                         QRMADD

                                         READMS *

                                         WRTETP +

                                         ZEROM


                    QRWAGN     calls     PRNTM

                                         QRMADD

                                         READMS *

                                         WRTETP +

                                         ZEROM
```

Table 8.—(Concluded)

READMS *

READTP +

REQFL +

WRITMS *

+ indicates DYLOFLEX library routine

* indicates 6600 system library routine

Table 8 (concluded)

3.6.1 INPUT DATA

The input data is from two sources, cards and magnetic files.

Card Input Data

For a complete description of all card input formats see section 6.0 in volume I of this document (User's Guide).

Tape Input Data

For a complete description of the tape input data see section 6.0 in volume I of this document (User's Guide).

3.6.2 OUTPUT DATA

The output data may be of two types, printed and magnetic files.

Printed Output Data

For a complete description of the printed output data see section 6.0 in volume I of this document (User's Guide).

Magnetic Files (Tape or Disk)

For a complete description of the magnetic file output data see section 6.0 in volume I of this document (User's Guide).

3.6.3 INTERNAL DATA

Two methods are used to pass data from one portion of the program to another, labeled common blocks and a scratch (temporary) storage random file SCRAND.

Magnetic File (Scratch Disk File)

EQMOD uses a random storage scratch disk file for temporary storage of data. All data are written on the random disk file SCRAND using subroutine WRITMS. Later, all data are read using the subroutine READMS. Table 9 shows the matrices written onto SCRAND. The contents of each matrix are then described on the following pages.

Table 9.—Contents of "SCRAND"

Matrix Description	Index Name	Variable Length
Edited EOM input data	EOMA	LNEOM
Edited LOADS input data	LODA, LODB,... LODT	LNLOD(1) LNLOD(2) LNLOD(20)
Edited QR input data	QRA, QRB,... QRT	LNGR(1) LNQR(2) LNQR(20)
Edited Derivative data	DERIV	LNDER
Edited Sensor data	SENSOR	LNSEN
Edited active control system definition data	SAS	LNSAS
Anti-symmetric body axis M_3 y_{col} vector	BOD	LNBOD
EOM matrices $\left\{\begin{matrix} M_1 \\ M_2 \\ M_3 \\ M_4 \\ M_5 \end{matrix}\right\}$ for QR	M1 M2 M3 M4 M5	LNM(1) LNM(2) LNM(3) LNM(4) LNM(5)
LOADS matrices $\left\{\begin{matrix} \bar{M}_1 \\ \bar{M}_2 \\ \bar{M}_3 \\ \bar{M}_4 \\ \bar{M}_5 \end{matrix}\right\}$ for QR time history	M1B M2B M3B M4B M5B	LNMB(1) LNMB(2) LNMB(3) LNMB(4) LNMB(5)
EOM matrix C_3 for QR time history	C3	LNC3
LOADS matrix $\bar{C}_3$ for QR time history	C3B	LNC3B

Edited EOM Input Data

File: SCRAND

Index name: EOMA

Dimensions: (82 + 15·NF+NREP+NINC)

where: NF = Number of frequencies
NREP = Number of elements to be replaced
NINC = Number of elements to be incremented data

Elements:

Item 1	INEOM, input EOM tape name
Item 2	INEOMF, file position number where EOM matrices are to be read from (after first read, set to zero)
Item 3	Pointer to header matrix of EOM input tape
Item 4	Pointer to header matrix of EOM output tape
Item 5	Pointer to scalar data
Item 6	Pointer to replacement data
Item 7	Pointer to increment data
Item 8 - 37	Header matrix of EOM input tape
Item 38 - 67	Header matrix of EOM output tape

Item 68 - (67+5+3·NF)
Scalar data

Item (73+3·NF) – (72+3·NF+10·NF+NREP)
Replacement data

Item (77+9·NF+NREP) – (78+9·NF+10·NF+NREP+NINC)
Increment data

Generation: Program RDEOM

Edited LOADS Input Data

File: SCRAND

Index name: LODA, LODB, ..., LODT (up to 20 LOAD sets)

Dimensions: (83+15·NF+NREP+NINC)

where: NF = Number of frequencies
NREP = Number of elements to be replaced
NINC = Number of elements to be incremented data

Elements:

Item 1	INLOD, input LOADS tape name
Item 2	INLODF, file position number where LOADS matrices are to be read from (after first read, set to zero)
Item 3	NLDOU, number of output loads
Item 4	Pointer to header matrix of LOADS input tape
Item 5	Pointer to header matrix of LOADS output tape
Item 6	Pointer to scalar data
Item 7	Pointer to replacement data
Item 8	Pointer to increment data
Item 9 - 38	Header matrix of LOADS input tape
Item 39 - 68	Header matrix of LOADS output tape
Item 69 - (68+5+3·NF)	Scalar data
Item (74+3·NF) – (73+3·NF+4+6·NF+NREP)	Replacement data
Item (78+9·NF+NREP)	Increment data

Generation: Program RDLOD

Edited QR Data

File:	SCRAND
Index name:	QRA, QRB, ..., QRT (up to 20 QR sets)
Dimensions:	70 x 1

Elements:

Item 1	INEOM, input EOM tape name
Item 2	INEOMF, file position number of EOM matrices
Item 3 - 32	Header matrix of EOM input tape
Item 33	ITYPE, indicator for QR process = 1, Wagner = 2, root = 3, time solution
Item 34	Wagner function, a
Item 35	Wagner function, b
Item 36	Wagner function α
Item 37	Wagner function, β

Item 38	INLOD, input LOADS tape name
Item 39	INLODF, file position number of LOADS matrices
Item 40	NLDQR, number of loads on LOADS tape
Item 41 - 70	Header matrix for LOADS input tape
Generation:	Program RDQR

Edited Derivatives Data

File:	SCRAND
Index name:	DERIV
Dimensions:	(21+7·NCS)
	where: NCS = Number of control surface

Elements:

Item 1	NCS, number of control surface
Item 2	$\left\{\begin{array}{l}\text{x col for symmetric}\\ \text{y col for antisymmetric}\end{array}\right\}$ column number of the $\left\{\begin{array}{c}x\\y\end{array}\right\}$ freedoms
Item 3	$\left\{\begin{array}{l}\text{z col for symmetric}\\ \phi\text{ col for antisymmetric}\end{array}\right\}$ column number of the $\left\{\begin{array}{c}z\\\phi\end{array}\right\}$ freedoms
Item 4	$\left\{\begin{array}{l}\theta\text{ col for symmetric}\\ \psi\text{ col for antisymmetric}\end{array}\right\}$ column number of the $\left\{\begin{array}{c}\theta\\\psi\end{array}\right\}$ freedoms
Item 5-(4+NCS)	δ_{col} column numbers of the δ control surface freedoms

Item (5+NCS) - (4+NCS+6)

Elements of EOM matrices, six values of

$\left\{\begin{array}{c}x_{col}\\y_{col}\end{array}\right\}$ first three for M_4 and next three for M_5

Item (5+NCS+6) – (4+NCS+12)

Elements of EOM matrices, six values of

$\left\{\begin{array}{c}z_{col}\\\phi\text{ col}\end{array}\right\}$ first three for M_4 and next three for M_5

Item (5+NCS+12) – (4+NCS+18)

Elements of EOM matrices, six values

$\left\{\begin{array}{c}\theta_{col}\\\psi_{col}\end{array}\right\}$ first three for M_4 and next three for M_5

Item (5+NCS+18) - (4+NCS+18+6·NCS)

For each control surface, NCS, repeat six value of δ_{col}; first three for M_4 and next three for M_5

Generation: Program RDEOM

Edited Sensor Data

File: SCRAND

Index name: SENSOR

Dimension: (9+2·NM1+2·NM2+2·NM3)

where: NM1 = Number of in/out row numbers for M_1 matrix

NM2 = Number of in/out row numbers for M_2 matrix

NM3 = Number of in/out row numbers for M_3 matrix

Elements:

Item 1 INSEN, input LOADS tape name of sensor

Item 2 INSENF, file position number where LOADS sensor matrices are to be read

Item 3 NLDSEN, number of loads on sensor matrices

Item 4 - 6 Null matrix indicators for three LOADS sensor matrices

Item 7 NM1, number of in/out row numbers for M_1 matrices

Item 8 NM2 number of in/out row numbers for M_2 matrices

Item 9 NM3, number of in/out row numbers for M_3 matrices

Item 10 - (9+2·NM1)

In row number of sensor matrix M_1 and out row number of EOM matrix M_1

Item (10+2·NM1)– (9+2·NM1+2·NM2)

In row number of sensor matrix M_2 and out row number of EOM matrix M_2

Item (10+2·NM1+2·NM2) – (9+2·NM1+2·NM2+2·NM3)

In row number of sensor matrix M_3 and out row number of EOM matrix M_3

Generation: Program RDEOM

Edited Active Control System Definition

File: SCRAND

Index name: SAS

Dimension: (1+5·NSAS) where NSAS = number of Active Control System data

Elements:

Item 1	NSAS, number of Active Control System data
Item 2	ISAS, ith row of augmented matrices
Item 3	JSAS, jth column of augmented matrices
Item 4	AM1IJ, value of Active Control System element for M_1 (I,J)
Item 5	AM2IJ, value of Active Control System element for M_2 (I,J)
Item 6	AM3IJ, value of Active Control System element for M_3 (I,J)
Generation:	Program RDEOM

Header Matrix in Edited EOM/LOADS Matrix

The header matrix contains thirty (30) words

Word	Contents	EOM/LOADS
1	7HYDLOFLX	
2	Program name/version; i.e., L217A1, L219A1, ...	
3	Date of run (10H yr/mo/da)	
4	NDOF, number of degrees of freedom	
5	NLD, number of load equations	
6	NPAN, number of panels	
7	NFREQM, number of frequencies	
8	$\bar{q}$, dynamic pressure	
9	V, velocity (true air speed)	
10 - 20	(future use)	
21	Null matrix indicator for	M_1, $\overline{M}_1$
22		M_2, $\overline{M}_2$
23		M_3, $\overline{M}_3$
24		M_4, $\overline{M}_4$
25		M_5, $\overline{M}_5$
26		M_6, $\overline{M}_6$
27		C_2, $\overline{C}_2$
28		C_3, $\overline{C}_3$
29		f_ℓ
30		$\tilde{\phi}, \overline{\tilde{\phi}}$

Note: If null matrix indicator is zero, the corresponding matrix is null and will not be on tape.

If null matrix indicator is greater than zero, the corresponding matrix does appear on tape.

Scalar Data in Edited EOM/LOADS Matrix

Word	Contents	EOM/LOADS
1	Scalar for matrix	$M_1, \overline{M}_1$
2		$M_2, \overline{M}_2$
3		$M_3, \overline{M}_3$
4		FREQM
5		$M_4, \overline{M}_4$
6		$M_5, \overline{M}_5$
7		$C_2, \overline{C}_2$
8		$C_3, \overline{C}_3$
9		f_ℓ
10		$\tilde{\phi}, \overline{\tilde{\phi}}$

Repeat words 5 through 10 for each frequency (NF) times.

Length is 3+5 * NF, where NF = number of frequencies.

Replacement Data in Edited EOM/LOADS Matrix

Word	Contents	EOM/LOADS
1	Replacement data pointer to/number of	$M_1, \overline{M}_1$
2		$M_2, \overline{M}_2$
3		$M_3, \overline{M}_3$
4		FREOM,
5	Repeat words 5 through 10 for each frequency (NF).	$M_4, \overline{M}_4$
6		$M_5, \overline{M}_5$
7		$C_2, \overline{C}_2$
8		$C_3, \overline{C}_3$
9		f_ℓ
10		$\tilde{\phi}, \overline{\tilde{\phi}}$

Word Content

First 30 bits	Second 30 bits
Pointer to replacement data	Number of replacement data for matrix

(5+6*NFREQM)
.
.
.
(4+6*NFREQM+NREP) — Replacement data

where: NF = Number of frequencies
NREP = Number of replacement values

Increment Data in Edited EOM/LOADS Matrix

Word	Contents	EOM/LOADS
1	Increment data pointers to/number of	$M_1, \overline{M}_1$
2		$M_2, \overline{M}_2$
3		$M_3, \overline{M}_3$
4		FREQM,
5	Repeat words 5 through 10 for each frequency (NF)	$M_4, \overline{M}_4$
6		$M_5, \overline{M}_5$
7		$C_2, \overline{C}_2$
8		$C_3, \overline{C}_3$
9		f_ℓ
10		$\Phi, \overline{\Phi}$

Word Content

First 30 bits	Second 30 bits
Pointer to increment data	Number of increment data

(5+6*NFREQM)
.
.
.
(4+6*NFREQM+NINC) — Increment data

where: NF = Number of frequencies
NINC = Number of increment values

Common Blocks

Table 10 shows the common blocks used in the program and the overlays in which they are defined.

The labeled common blocks are used for communication between the primary and secondary overlays. The block names and contents are described in table 11.

Table 10.—Common Blocks Defined in Each Overlay

OVERLAYS	COMMON BLOCKS											
	BODYAX	HEADER	INOUT	KEYWRD	NERROR	OUTVOL	PRNTOP	PROBSZ	SCRANF	TITLE	RWBUFF	Blank
L219,0,0 L119vc	X	X	X	X	X	X	X	X	X	X	X	X
L219,1,0 RDCRDS		X	X	X	X	X	X	X		X		
L219,1,1 RDEOM	X	X	X	X	X		X	X	X			
L219,1,2 RDLOD		X	X	X	X		X	X	X			
L219,1,3 RDQR			X	X	X	X	X	X	X			
L219,2,0 EOMMOD			X		X		X	X	X	X		
L219,3,0 LODMOD			X		X		X	X	X	X		
L219,4,0 QRMOD			X		X	X	X	X	X	X		

Table 11.—Common Block Names and Contents

LABELED COMMON NAME: BODYAX

DESCRIPTION: Body axis input data.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	IBODYA	I			Indicator for body axis = 0, no body axis ≠ 0, perform body axis transformation
2	ICOLX	I			X_{col} the column in the matrices which are changed by the symmetric body axis transformation
3	ICOLZ	I			Z_{col} the column in the matrices which are changed by the symmetric body axis transformation
4	ICOLT	I			Θ_{col} the column in the matrices which are changed by the symmetric body axis transformation
5	ICOLY	I			Y_{col} the column in the matrices which are changed by the antisymmetric body axis transformation
6	ICOLP	I			ϕ_{col} the column in the matrices which are changed by the antisymmetric body axis transformation
7	ICOLS	I			Ψ_{col} the column in the matrices which are changed by the antisymmetric body axis transformation
8	BODYA1	R			α_1, angle of attack for body axis transformation
9	BODYVT	R			V_T, velocity (true air speed) for body axis transformation

NOTE: The "T" heading refers to variable type:

I - Integer
R - Real
C - Complex
L - Logical
H - Hollerith

Table 11.—(Continued)

LABELED COMMON NAME: HEADER

DESCRIPTION: Header matrix first nine (9) words.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	IWORD1	H			The literal DYLOFLEX
2	IWORD2	H			Program's name/version which is the literal "L219A1"
3	IWORD3	H			Date of run, YR/MO/DA
4	IWORD4	I			Number of degrees of freedom, NDOF
5	IWORD5	I			Number of load equations, NLD
6	IWORD6	I			Number of gradual penetration panels, NPAN
7	IWORD7	I			Number of frequencies, NFREQM
8	WORD8	R		$\bar{q}$	Dynamic pressure
9	WORD9	R		V_T	Velocity (true air speed)

Table 11.–(Continued)

LABELED COMMON NAME: KEYWRD

DESCRIPTION: Keyword record (card image and code number)

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	IREAD	I			Indicator for reading next card = 0, read next card = 1, do not read next card
2	ICODE	I			Keyword code number associated with keyword table
3	ICARD	H	8		Card image of last input data read

Table 11.—(Continued)

LABELED COMMON NAME: NERROR

DESCRIPTION: Error indicators and accumulators.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NFATAL	I			Number of fatal errors accumulated
2	NWARN	I			Number of warning errors accumulated
3	IRR	I			Error number returned from subroutine called

Table 11.—(Continued)

LABELED COMMON NAME: OUTVOL

DESCRIPTION: Output volumes and file position.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	IUTEOM	H			Output EOM tape name, EQEOM
2	IFLEOM	I			File position number where EOM Matrices will be written
3	IUTLOD	H			Output LOADS tape name, EQLOD
4	IFLLOD	I			File position number where LOADS matrices will be written
5	IUTQR	H			Output QR tape name, QRTAP
6	IFLQR	I			File position number where QR matrices will be written

Table 11.—(Continued)

LABELED COMMON NAME: PRNTOP

DESCRIPTION: Print Options

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	INPR	I			Print options for input matrices: = -999, print all input matrices = 0, no input matrix printed = I, only matrices of the Ith frequency printed
2	IUTPR	I			Print options for output matrices: = -999, print all output matrices = 0, no output matrix printed = I, only matrices of Ith frequency printed = 999, only modified matrices printed.
3	ICKPR	I			Checkout print option = 0, no checkout print ≠ 0, checkout print. All matrices (I/O) and intermediate results printed. Used for debugging purposes only.

Table 11.—(Continued)

LABELED COMMON NAME: PROBSZ

DESCRIPTION: Problem size.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NDOF	I			Number of total degrees of freedom ($\leq$ 100)
2	NDOFI	I			Number of degrees of freedom read from input tape
3	NPAN	I			Number of total panels ($\leq$ 50)
4	NFREQM	I			Number of frequencies ($\leq$ 20)
5	ISYMM	I			Indicator for type of analysis: = 0, symmetric $\neq$ 0, anti-symmetric

Table 11.—(Continued)

LABELED COMMON NAME: SCRANF

DESCRIPTION: Scratch random file (SCRAND) matrix names and lengths.

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NEOM	I			Number of EOM sets
2	MAXEOM	I			Maximum number of EOM sets ($\leq$ 1)
3	LNEOM	I			Length of edited EOM input data
4	NAMEOM	H			Matrix name of edited EOM input data
5	NLOD	I			Number of LOADS sets
6	MAXLOD	I			Maximum number of LOADS set ($\leq$ 20)
7	LNLOD	I	20		Lengths of edited LOADS input data
8	NAMLOD	H	20		Matrix name of edited LOADS input data
9	NQR	I			Number of QR sets
10	MAXQR	I			Maximum number of QR sets ($\leq$ 20)
11	LNQR	I	20		Length of edited QR input data
12	NAMQR	H	20		Matrix name of edited QR input data
13	LNDER	I			Length of edited derivative data
14	NAMDER	H			Matrix name of edited derivative data
15	LNSEN	I			Length of edited sensor data
16	NAMSEN	H			Matrix name of edited sensor data
17	LNSAS	I			Length of edited active control system data definition
18	NAMSAS	H			Matrix name of edited active control system data definition
19	LNBOD	I			Length of anti-symmetric body axis M_3 y_{col} vector
20	NAMBOD	H			Matrix name of anti-symmetric body axis M_3 y_{col} vector

Table 11.—(Continued)

LABELED COMMON NAME: SCRANF (concluded)

DESCRIPTION:

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
21	LNM	I	5		Length of EOM matrices for QR
22	NAMM	H	5		Matrix names of EOM matrices for QR
23	LNMB	I	5		Length of LOADS matrices for QR time history
24	NAMMB	H	5		Matrix names of LOADS matrices for QR time history
25	LNC3	I			Length of EOM C_3 matrix for QR time history
26	NAMC3	H			Matrix name of EOM C_3 matrix for QR time history
27	LNC3B	I			Length of LOADS $\overline{C}_3$ matrix for QR time history
28	NAMC3B	H			Matrix name of LOADS $\overline{C}_3$ matrix for QR time history

Table 11.–(Continued)

LABELED COMMON NAME: TITLE

DESCRIPTION: Title card

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	NTITLE	I			Number of title cards
2	ITITLE	H	(8,4)		Title cards to be printed at beginning of printed output

Table 11.—(Concluded)

LABELED COMMON NAME: RWBUFF

DESCRIPTION: RWBUFF for subroutines READTP/WRTETP

NO.	VARIABLE	T	DIM.	ENG. NOM.	DESCRIPTION
1	IBUFF	H/I	2		Array of two words First word contains 8HBUFFSIZE Second word contains the buffer size, 10000.
2	BUFF	R	10,000		Buffer area when using routines READTP and WRTETP.

BLANK common is used in all secondary overlays and most primary overlays as a variable length working area. In general the main program of an overlay calculates the area required for arrays in the various subroutines and passes a dimension and first word address of each array through the subroutine calling sequence. A description of the area used by each overlay is given in figure 12. The BLANK common required varies with problem size. Section 6.2, volume I of this document, explains how to calculate the core storage required for a particular problem.

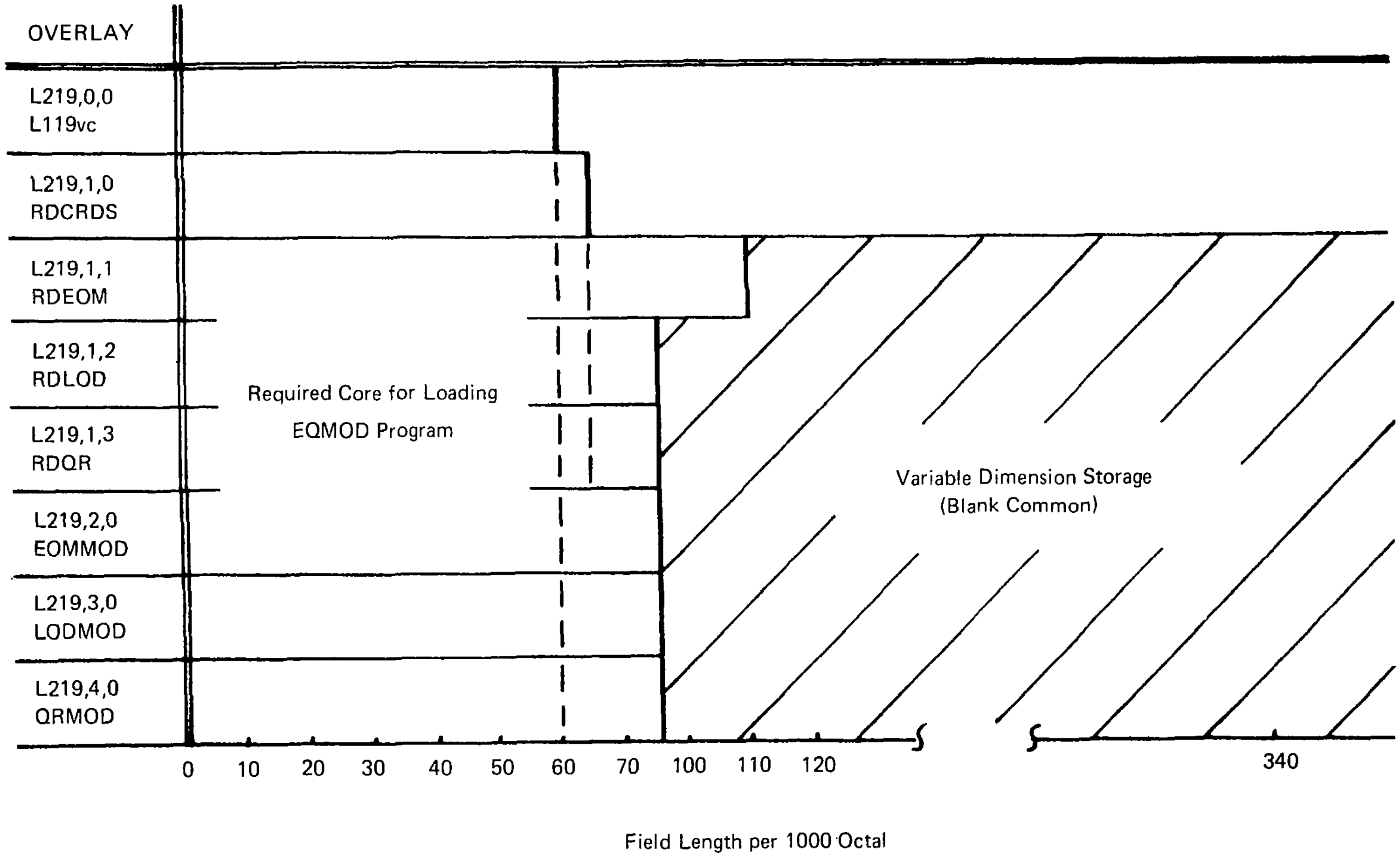


Figure 12.—Overlay Core Requirements and Blank Common Working Area

4.0 EXTENT OF CHECKOUT

Five different data cases were assembled to test L219 (EQMOD). The various options used are displayed in table 12. The results for each test case were compared against hand calculated answers.

Table 12.—Options Used in Checkout Data Cases

	Options and Major Paths	Cases 1	2	3	4	5
1	Problem size	X	X	X	X	X
2	Output tape specification	X	X	X		X
3	Symmetric analysis	X	X	X		X
4	Anti-symmetric analysis				X	
5	Body axis transformation			X	X	
6	Equation of motion data	X	X	X	X	X
7	Sensor	X	X		X	X
8	Derivatives from card		X			X
9	Derivatives from tape (FLEXSTAB)	X			X	
10	Unsteady derivatives		X			
11	SAS	X				X
12	Scale EOM matrices			X		
13	Replace EOM matrices		X			
14	Increment EOM matrices		X			
15	Loads equation data		X	X	X	
16	Scale LOADS matrices		X			
17	Replace LOADS matrices			X		
18	Increment LOADS matrices			X		
19	QR data		X		X	
20	Wagner option		X			
21	Root option		X		X	
22	Time option		X		X	
23	Diagnostics					

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15. Supplementary Notes

Langley Technical Monitors: Robert C. Goetz and Boyd Perry III
Topical Report

16. Abstract

L219 (EQMOD) is a digital computer program available for execution on the CDC 6600. The progam modifies matrices according to card input instructions and prepares magnetic files of matrices suitable for use in the Linear Systems Analysis program (QR) and the Random Harmonic Analysis program L221 (TEV156).

The particular field of application of the program is the modification of the theoretical equations of motion and load equations generated in DYLOFLEX by the Equation of Motion program (L217) and the Load Equation program (L218), respectively.

Program usage and a brief description of the analysis used are presented in volume I of this document. Volume II contains a description of the design and structure of the program to aid those persons who will maintain and or modify the program in the future.

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